

CLAIMS

We claim

- 1 1. A multi-level waveguide comprising:
2 a first substrate having a first opening therethrough;
3 a second substrate, attached to said first substrate, having a second opening
4 therethrough and aligned with the first opening in said first substrate;
5 a transparent material inserted in said first substrate hole; and
6 a transparent material inserted in said second substrate hole.
- 1 2. The multi-level waveguide of claim 1, wherein said transparent material is a gas.
- 1 3. The multi-level waveguide of claim 1, wherein said transparent material is
2 cladding grown on the inside of the substrate hole.
- 1 4. The multi-level waveguide of claim 1, wherein said transparent material is
2 comprised of an outer cladding and a separate inner transparent material.
- 1 5. The multi-level waveguide of claim 1, wherein said transparent material is an
2 optical fiber.
- 1 6. The multi-level waveguide of claim 1, wherein said first substrate is made of
2 silicon.
- 1 7. The multi-level waveguide of claim 1, wherein said transparent material and said
2 first substrate are made of the same material.
- 1 8. The multi-level waveguide of claim 1 further comprising a source of
2 electromagnetic radiation attached to said first substrate.
- 1 9. The multi-level waveguide of claim 1 further comprising a detector of
2 electromagnetic radiation attached to said second substrate.

1 10. The multi-level waveguide of claim 1 further comprising a conductive layer on
2 said second substrate.

1 11. A method of making a multi-level waveguide comprising:
2 etching a hole in a first substrate;
3 etching a hole in a second substrate;
4 lithographically aligning said first substrate hole to said second substrate hole; and
5 attaching said first substrate to a second substrate.

1 12. The method of claim 11 further comprising growing a cladding in said first
2 substrate hole before lithographically aligning said first substrate hole to said second
3 substrate hole

1 13. The method of claim 11, further comprising:

2 radially growing a cladding on walls of said first substrate hole to a depth less
3 than the first substrate hole's radius; and

4 inserting transparent material having an index of refraction greater than an index
5 of refraction of the cladding material into said first substrate hole before lithographically
6 aligning said first substrate hole to said second substrate hole.

1 14. The method of claim 11, wherein said aligning comprises:

2 placing a solder bump on said first substrate relative to said first substrate hole;
3 placing a metal pad on said second substrate relative to said second substrate hole;
4 moving said first substrate and said second substrate relative to each other to
5 contact said solder bump to said metal pad; and
6 melting said solder bump to said metal pad.

1 15. The method of claim 11, wherein said aligning comprises:

2 etching a marker hole in said first substrate relative to said first substrate hole;
3 etching a marker hole in said second substrate relative to said second substrate
4 hole;

5 moving said first substrate and said second substrate relative to each other until a
6 source of electromagnetic radiation radiates through said first substrate marker hole and
7 said second substrate marker hole; and

8 detecting said source of electromagnetic radiation with a detector of
9 electromagnetic radiation.

1 16. The method of claim 11 further comprising applying conductive layers on said
2 first substrate.

1 17. A multi-level waveguide comprising:
2 a first substrate having a first opening therethrough;
3 a substantially horizontal core pathway on top of said first substrate; and
4 a cladding layer on top of said core pathway.

1 18. The multi-level waveguide of claim 17, wherein a layer of cladding is between
2 said first substrate and said horizontal core pathway.

1 19. The multi-level waveguide of claim 17, further comprising a marker on said first
2 substrate

1 20. A method of making a multi-level waveguide comprising:
2 depositing core material on a first substrate;
3 patterning said core material with a mask;
4 etching said patterned core material; and
5 depositing a cladding layer on said core material.

1 21. The method of claim 20 further comprising depositing a layer of cladding on said
2 first substrate before depositing said core material.

1 22. The method of claim 20 further comprising etching a hole in said first substrate.

1 23. The method of claim 20 further comprising:

2 etching a hole in a second substrate;

3 aligning said first substrate hole to said second substrate hole; and

4 attaching said first substrate to said second substrate.

1 24. A method of making a multi-level waveguide comprising:

2 etching a hole in a first substrate;

3 etching a hole in a second substrate;

4 heating said first substrate;

5 inserting an optical fiber into said first substrate hole;

6 lithographically aligning said first substrate to said second substrate; and

7 attaching said first substrate to said second substrate.

1 25. The method of claim 24, wherein said first substrate is heated to a temperature
2 between approximately 75 °C and 175 °C.

1 26. The method of claim 24 further comprising applying a conductive layer to said
2 second substrate.

1 27. The method of claim 24, wherein said aligning comprises:
2 placing a solder bump on said first substrate relative to said first substrate hole;
3 placing a metal pad on said second substrate relative to said second substrate hole;
4 moving said first substrate and said second substrate relative to each other to
5 contact said solder bump to said metal pad; and
6 melting said solder bump to said metal pad.

1 28. The method of claim 24, wherein said aligning comprises:
2 placing a solder bump on said first substrate relative to a first substrate optical
3 fiber core;
4 placing a metal pad on said second substrate relative to a second substrate optical
5 fiber core;

moving said first substrate and second substrate relative to each other to contact
said solder bump to said metal pad; and
melting said solder bump to said metal pad.

29. The method of claim 24, wherein said aligning comprises
etching a marker hole in said first substrate relative to at said first substrate hole;
etching a marker hole in said second substrate relative to said second substrate
hole;

moving said first substrate and said second substrate relative to each other until a
source of electromagnetic radiation radiates through said first substrate marker hole and
said second substrate marker hole; and

detecting said source of electromagnetic radiation with a detector of
electromagnetic radiation.

30. The method of claim 24, wherein said aligning comprises
etching a marker hole in said first substrate relative to a first substrate optic fiber
core;

etching a marker hole in said second substrate relative to a second substrate optic
fiber core;

moving said first substrate and said second substrate relative to each other until a
source of electromagnetic radiation radiates through said first substrate marker hole and
said second substrate marker hole; and

detecting said source of electromagnetic radiation with a detector of
electromagnetic radiation.